RAS 5773 72-22-ISFSI-Staff Exhibit GG-Recd 5/7/02

Staff GG.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

January 22, 2002

DOCKETED
USNRC

2003 FEB -5 AM 9:25

OFFICE OF THE SECRETARY
RULEMAKINGS AND
ADJUDICATIONS STAFF

MEMORANDUM TO: Daniel H. Dorman, Chief
Engineering Research Applications Branch
Division of Engineering Technology
Office of Nuclear Regulatory Research

FROM: S. Khalid Shaukat Syed K. Shaukat
Engineering Research Applications Branch
Division of Engineering Technology
Office of Nuclear Regulatory Research

SUBJECT: REVIEW PANEL MEETING ON SEISMIC BEHAVIOR OF SPENT FUEL STORAGE CASK SYSTEMS (NOVEMBER 15-16, 2001)

The NRC NMSS/RES staff had the third Review Panel Meeting with the contractor, Sandia National Laboratories (SNL), and review panel members to discuss the plan of action for the project on seismic behavior of spent fuel storage cask systems for short term goals as well as long term goals. The meeting took place on November 15-16, 2001 at the NRC headquarters. A list of meeting attendees is provided in Attachment 1.

The project was initiated in response to NMSS user need request dated March 27, 1998. The NRC is providing 3 staff members and EPRI is providing 4 staff members to the review panel.

The meeting started with the discussion of available information on cask design, concrete pad design, cask/pad interface, interaction with soil/foundation, seismic characteristics, analysis methods and test data. The following is the summary of items identified regarding the analyses of casks behavior under seismic loads:

With the recommendations from Review Panel, we all agreed to proceed with the following course of action:

- Additional parametric analyses for two cask designs (a horizontal rectangular module and a vertical cylindrical cask) will be performed as follows:.
    - For rectangular module use 5 earthquakes (3 levels of E.Q. using R.G. 1.60 spectra and additional 2 spectrum compatible Taiwan and Tabas earthquakes scaled to 1g).
    - For cylindrical casks use 5 earthquakes (3 levels of E.Q. using R.G. 1.60 spectra and additional 2 spectrum compatible Taiwan and Tabas earthquakes scaled to 1g), and two cask designs (1 by Holtec, and 1 other design by another vendor e.g., BNFL or NAC).

Template = SECY-028

SECY-02

Use 3 coefficients of friction (0.3, 0.5, 0.75) for both rectangular module and cylindrical casks. This range will cover friction between steel to concrete as well as between concrete to concrete, although it is recognized that friction between concrete to concrete is higher than friction between steel to concrete.

This will make a total of 150 parametric analyses.

- Perform additional 10 parametric analyses for casks on rock foundation.
    - For SONGS site use site specific time histories scaled to 0.67g, and 2 coefficient of frictions (0.4 and 0.5) with 3 different soil properties (low, best and high estimate). Also re-run the analyses using Tabas E.Q. with PGA 1.5g horizontal, and R.G. 1.60 spectra for 1.5g.
    - For Private Fuel Storage (PFS) Facility site perform additional site-specific sensitivity analyses for the HOLTEC cylindrical cask as follows:
    - Perform additional seismic analyses of a full-scale coupled nonlinear model of a single cask/pad/soil-cement/soil column for a 10,000 year return earthquake with three case of soil properties (low, best and high estimate). Seismic time histories are provided by the NRC.

SNL will submit to the NRC the interim reports for the short term goals of SONGS and PFS sites and a draft NUREG/CR report covering all technical findings of generic parametric analyses for the long term goals.

Attachment: As stated

CONTACT: Khalid Shaukat,
301-415-6592

Attachment 1

Dry Cask Storage Systems
Third Review Panel Meeting
November 15-November 16, 2001
NRC, Rockville, MD

Name	Affiliation	Phone Number	E-mail Address
Goutam Bagchi	NRC/NRR	301-415-3305	gxb1@nrc.gov
Nilesh Chokshi	NRC/RES	301-415-6013	ncc1@nrc.gov
Robert Dameron	Anatech Corp.	858-455-6350	rad@anatech.com
Jack Guttmann	NRC/NMSS	301-415-8576	jxg@nrc.gov
M. Wayne Hodges	NRC/NMSS	301-415-2398	mwh@nrc.gov
Bob Kassawara	EPRI	650-855-2775	rkassawa@epri.com
Robert P. Kennedy	RPK Struct.Mech.	760-751-3510	rpkstruct@earthlink.net
K. C. Leu	NRC/NMSS	301-415-8543	kcl@nrc.gov
Vincent K. Luk	Sandia NL	505-844-5498	vkluk@sandia.gov
Donald P. Moore	Southern	205-992-6672	dpmoore@southernco.com
Andrew Murphy	NRC/RES	301-415-6011	ajm1@nrc.gov
Joe Rashid	Anatech Corp.	858-455-6350	joe@anatech.com
Mahendra Shah	NRC/NMSS	301-415-8537	mjs3@nrc.gov
Khalid Shaukat	NRC/RES	301-415-6592	sks1@nrc.gov
Jeffrey Smith	Sandia NL	505-845-0299	jasmith@sandia.gov
Torrey Yee	Southern CA Ed.	949-368-2338	yeet@songs.sce.com

Dry Cask Storage Systems (DCSS)
Second Review Panel Meeting

October 31-November 1, 2000

The meeting focused on behavior of DCSS under seismic loads for a short term goal (December 31, 2000 deadline) and a long term goal (efforts for 2001 and beyond).

- December 31 Deadline: Provide confirmatory analyses to help the staff in review of the cask vendor's (Transnuclear West) submittal for Modules of casks storage at San Onofre site. The staff must have this information by Dec. 31, 2000.

- Efforts for 2001 and Beyond: Provide insights to the behavior of casks/pad/soil systems with generic studies of different designs of casks on sites of different soil stiffness with a range of seismic loads, and to provide support to NRC in revising the regulatory guidelines for the DCSS. This effort will take at least two more years.

DECEMBER 31 DEADLINE:

Both Sandia (SNL) and Anatech presented the results of independent non-linear analyses of a coupled finite element model of Rectangular Module, Pad, and Soil underneath for the Transnuclear West design of the DCSS system.

The following elements were the focus:

- Coupled model for Transnuclear West module/cask with pad and foundation

- Modeling approaches and details

- Seismic time histories whose frequency content are based on the Taiwan earthquake records have been used.

- Soil properties used were reviewed and it was agreed that actual soil properties of the soil at San Onofre site will be used.

- Coefficients of friction at module/pad interface used was static, but the consensus was that dynamic coefficient of friction will be used in the final analyses.

- Coefficients of restitution was not considered. But the consensus was to use some meaningful number (in the range of 0.1 to 0.25) to be determined by some non-linear analyses and SNL/Anatech agreed to do that.

There were some differences in the independent analyses by SNL and Anatech. Both of them used 3D solid elements in the coupled model. Only one rectangular module/cask was used with a base of concrete extending 10 ft all around the module. There were slight differences in modeling applying seismic loads. The results were slightly different

but overall conclusion was not too different. The difference may be caused by the different damping factors used in the soil foundation model, and different meshing for the module model. Both analyses showed sliding and tipping in some orientations. This was expected as Transnuclear West preliminary studies for a single module showed similar results. That's why Transnuclear West decided to tie 3 modules together, and the mass is heavy enough not to trip the casks.

After the presentation and discussion by the attendees it was the consensus that the approach is generally right, and, with the budget and time restraints, the following was agreed upon for the finished product for the December deadline:

SNL and Anatech will come up with one integrated approach for modeling and applying seismic motion and generate one set of results. Analyses will be modified for a system of 3 modules tied together (actual design by Transnuclear West) with attached shield walls resting freely on a concrete pad and the best estimate parameters will be used for coefficient of restitution, and soil damping factors with a range of coefficient of friction between cask and the pad. Seismic load will be applied using R.G. 1.60 spectrum scaled to 1.25g that is estimated to give a response of 1.5g at the center of gravity of the cask. This will best match the zero period acceleration (ZPA) used in the submittal by the applicant.

ANALYSIS TASKS FOR 2001 AND BEYOND:

Meaningful discussion about the approach of analyzing a generic DCSS on sites of different soil stiffness with a range of seismic loads helped define the course of action to achieve the objectives in the time and budget restraints. Two geometries of the casks (Rectangular Module, and Cylindrical cask) will be considered.

Rectangular Module: (54 cases to be analyzed)

- Use 1 Rectangular Module on concrete pad of 10 ft. all around.
- Contact surface for Rectangular Module is concrete on concrete. (Use coefficient of friction 0.3, 0.5, 0.75)
- Seismic Loading: Use 4 R.G. 1.60 spectra scaled to a range of PGA, 1 artificial time history from Taiwan earthquake scaled to 1.5 g, and 1 real time history from Tabas earthquake scaled to 1.5 g.
- Use 3 different soil types (stiff, medium, and soft)

Cylindrical Cask: (120 cases to be analyzed)

- Use two types of single cylindrical cask from different vendors)
- A sensitivity study will be done to determine how many nodes to be used in the model of cylindrical cask.

- Contact surface for cylindrical casks is steel on concrete. (Use a range of coefficient of friction at least three with thermal effects in consideration)
- Seismic Loading: Use 1 Utah site specific and 4 R.G. 1.60 spectra scaled to a range of PGA.
- Soil/Rock Foundation: Use 4 different types

It was pointed out by NMSS that by June 2001, it would be desirable to see the analyses for cylindrical cask, because there is a hearing planned for Public Fuel Storage (PFS) facility at Utah. Therefore, the priority of the tasks should be set accordingly. From Utah site specific spectra, 3 time histories need to be generated for this study.

An interim report on generic studies specially on cylindrical cask would be provided by SNL by April or May 2001. A third Review Panel Meeting may be scheduled immediately after the interim report.

Dry Cask Storage Systems
Second Review Panel Meeting
October 31-November 1, 2000
NRC, Rockville, MD

	Name	Affiliation	Phone Number	E-mail Address
✓	Goutam Bagchi	NRC/NRR	301-415-3305	gxb1@nrc.gov
	Nilesh Chokshi	NRC/RES	301-415-6013	ncc1@nrc.gov
✓	Robert Dameron	Anatech Corp.	858-455-6350	rad@anatech.com
✓	M. Wayne Hodges	NRC/NMSS	301-415-2398	mwh@nrc.gov
✓	Bob Kassawara	EPRI	650-855-2775	rkassawa@epri.com
✓	Roger M. Kenneally	NRC/RES	301-415-6303	rmk@nrc.gov
✓	Robert P. Kennedy	RPK Struct.Mech.	714-777-2163	rpkstruct@earthlink.net
✓	K. C. Leu	NRC/NMSS	301-415-8543	kcl@nrc.gov
✓	Vincent Luk	Sandia NL	505-844-5498	vkluk@sandia.gov
✓	Donald Moore	Southern	205-992-6672	dpmoore@southernco.com
	Andrew Murphy	NRC/RES	301-415-6982	ajm1@nrc.gov
✓	Joe Rashid	Anatech Corp.	858-455-6350	joe@anatech.com
✓	Khalid Shaukat	NRC/RES	301-415-6592	sks1@nrc.gov
✓	Jeffrey Smith	Sandia NL	505-845-0299	jasmith@sandia.gov
✓	Torrey Yee	Southern CA Ed.	949-368-2338	yeet@songs.sce.com
	Sudhaway Basu	NRC/RES	301-415-6774	sxb2@nrc.gov

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

March 10, 2000

MEMORANDUM TO: Edwin M. Hackett, Acting Branch Chief
Materials Engineering Branch
Division of Engineering Technology
Office of Nuclear Regulatory Research

FROM: S. Khalid Shaukat
Materials Engineering Branch
Division of Engineering Technology
Office of Nuclear Regulatory Research

S. K. Shaukat

SUBJECT: REVIEW PANEL MEETING ON SEISMIC BEHAVIOR OF SPENT FUEL STORAGE CASK SYSTEMS (FEBRUARY 24-25, 2000)

The RES staff had the first meeting with the contractor, Sandia National Laboratories (SNL), and review panel members to discuss the plan of action for the project on seismic behavior of spent fuel storage cask systems. The meeting took place on February 24-25, 2000 at Electric Power Research Institute (EPRI) facilities in Palo Alto, CA. A list of meeting attendees is provided in Attachment 1.

The project was initiated in response to NMSS user need request dated March 27, 1998. The NRC and EPRI are each providing 4 staff members to the review panel.

The meeting started with the discussion of available information on cask design, concrete pad design, cask/pad interface, interaction with soil/foundation, seismic characteristics, analysis methods and test data. The following is the summary of items identified regarding the analyses of casks behavior under seismic loads:

A) Operating spent fuel storage sites and potential near term new sites in low and high seismicity areas.

B) Two types of cask designs in use by the industry: 1) massive horizontal rectangular casks with aspect ratio less than one, and 2) Vertical cylindrical casks with aspect ratio greater than one.

C) Two categories of concrete pad design in use by the industry: 1) thin pads with thickness ranging between 18 and 24 inches, and 2) thick pads with thickness ranging 36 inches and more.

D) For interfacial contact between casks and pads two types of contact surfaces in use by the industry: 1) steel cask on concrete, and 2) concrete cask/housing on concrete. It was acknowledged that moisture content at surfaces is dominating factor that affects significantly on the friction coefficient for sliding behavior of casks. Also mentioned was that a guidance on coefficient of friction needs to be prepared for the benefit of the NRC reviewers as well as

industry use, and some test data must be looked into developing such guidance. For casks behavior under seismic loadings, both sliding and rocking/overturning mechanisms must be considered.

E) Seismic analyses must consider soil-structure interaction (SSI) with the variation of pad thicknesses and soil or rock foundation (soft soil, firm soil, hard rock etc.) beneath the pad.

Pad flexibility is dominant with thin pads specially on soft soil. Various seismic time histories will be considered.

F) The only available test data is CRIEPI test data of Japan, which was conducted on 1/5- and 1/3- scale model of a freestanding cask.

It was suggested that the following line of action should be pursued for this project:

1. Document the parameters important for evaluation. During Phase I of this project the literature was searched for applicable parameters. The parameters recommended for consideration by the review panel are:

- Coefficient of Friction: Determine the range (e.g., 0.3 to 0.7) for cask/pad interface (steel on concrete and concrete on concrete) after searching some bounding values in the literature. Look at moisture conditions and other conditions of contact surfaces.

- Coefficient of Restitution: It was recognized that not enough data exists for this, and Argonne National Laboratory has some values based on static analyses. This coefficient is very low (e.g., 0.25 may be a lower bound as any value less than that does not yield any different results).

- Cask Designs: Vertical cylindrical cask and Horizontal rectangular cask. Bound some variations in a reasonable way, (e.g., one model with center of gravity height equal to diameter of cylinder or width of rectangle).

2. For seismic ground motion characteristics, start with real earthquake record - as Fourier amplitude spectra and select the one that reasonably fits R.G. 1.60 spectra, or enrich it to look like R.G. 1.60 spectra. Apply 2 orthogonal components of ground motion with vertical component.

3. Perform soil/foundation/cask-interaction analyses. Soil-Structure-Interaction (SSI) effects should be considered with flexibility of the pad and effects of sliding and rocking motion. Perform a linear analysis with SSI and flexibility of pads and nonlinear analysis for sliding/rocking motion of the cask. Take the time history from linear analysis at the CG of the cask and applying it at the base mat considering rigid mat and do nonlinear analyses of cask response. These analyses can be performed to benchmark a full scale coupled nonlinear analysis, and then some simple approaches can be developed.

4. Perform sensitivity analyses considering a range of important parameters and cask configuration to develop nomograms. EPRI had developed a pad/subgrade hardness factor for

cask impact analyses that reduce the amount of analyses to develop the nomograms. EPRI will provide reports so this concept can be evaluated.

5. Perform finite element analyses using CRIEPI data to validate analytical methods. It was noted that there are problems with this approach because the data (e.g., time history input and cask response, no measurement of table motion, etc.) are lacking.

6. Identify if test is needed to validate analyses.

Attachment: As stated

CONTACT: Khalid Shaukat, MEB/DET/RES
301-415-6592

Distribution:
GBagchi, NRR
JLyons, NMSS
KLeu, NMSS
MMayfield
SBahadur
NChokshi
Rkenneally

DET r/f MEB r/f ERAB r/f

DOCUMENT NAME: G\:Shaukat\caskTrip.wpd
To receive a copy of this document, indicate in the box: "C" = Copy without attachment/enclosure "E" = Copy with attachment/enclosure "N" = No copy

OFFICE	MEB/DET/RES
NAME	S. K. Shaukat SKS
DATE	03/10/00

cask impact analyses that reduce the amount of analyses to develop the nomograms. EPRI will provide reports so this concept can be evaluated.

5. Perform finite element analyses using CRIEPI data to validate analytical methods. It was noted that there are problems with this approach because the data (e.g., time history input and cask response, no measurement of table motion, etc.) are lacking.

6. Identify if test is needed to validate analyses.

Attachment: As stated

CONTACT: Khalid Shaukat, MEB/DET/RES
301-415-6592

Attachment 1

Cask Review Panel Meeting
February 24-25, 2000
EPRI - Palo Alto, CA

Name	Affiliation	Phone Number	E-mail Address
Bob Kassawara	EPRI	650-855-2775	rkassawa@epri.com
Khalid Shaukat	NRC/RES	301-415-6592	sks1@nrc.gov
Donald Moore	Southern	205-992-6672	dpmoore@southernco.com
Robert P. Kennedy	RPK Struct.Mech.	714-777-2163	rpkstruct@earthlink.net
Vincent Luk	Sandia NL	505-844-5498	vkluk@sandia.gov
Jim Lyons	NRC/NMSS	301-415-8540	jel@nrc.gov
Joe Rashid	Anatech	858-455-6350	joe@anatech.com
Torrey Yee	Southern CA Ed.	949-368-2338	yeet@songs.sce.com
Goutam Bagchi	NRC/NRR	301-415-3298	gxb1@nrc.gov
Albert Machiels	EPRI	650-855-2054	amachiel@epri.com
Roger M. Kenneally	NRC/RES	301-415-6303	rmk@nrc.gov
K. C. Leu	NRC/NMSS	301-415-8543	kcl@nrc.gov

NUCLEAR REGULATORY COMMISSION

Docket No. 72-22 Official Exh. No. GG

In the matter of PFS

Staff ✓	IDENTIFIED ✓
Applicant	RECEIVED ✓
Intervenor	REJECTED
Other	WITHDRAWN
DATE 5-7-02	Witness
Clerk pmp	